Multipollutant Emission Reduction and CO_2 Control: The Costs of Regulatory Uncertainty

Timothy L. Johnson and David W. Keith

Carnegie Mellon University

tjohnson@cmu.edu and keith@cmu.edu

07 May 2003

Overview

- Motivation
- Multipollutant Control Scenarios: Technology paths and mitigation costs
- Value of Information: The cost of regulatory uncertainty

Motivation

- Technological Synergies: The marginal cost of CO_2 control via carbon capture and sequestration (CCS) would likely be less for electric power plants that must meet stronger "3P" (SO_2, NO_X, Hg) emission limits than for those that do not.
- Uncertainty regarding the timing, stringency, and integration of the associated emission limits, however, may impose significant costs.

MP and CCS: Key Questions

- What is the economic value of coherent multipollutant (MP) regulation?
- When is the value of knowledge greatest? What scenarios produce a significant value of information effect?

Analytical Perspective

- Middle ground niche
  - An electric system model: more technology than macroeconomic assessments, more endogenous economics than plant-level analyses
  - Timeframe: between Kyoto (now less than a decade) and integrated assessment models (~ 100 years)

Need to Consider:

- Plant dispatch
- Temporal dynamics: gas prices and demand
- Existing generating capacity (sunk capital)
- Regulatory timing

An Electric Sector Dispatch Model

- Bottom-up, engineering-economic framework
- Determines: (1) new capacity and (2) utilization of installed capacity for each time period to minimize NPV of total costs
- Meets demand for the MAAC NERC region (the centrally-dispatched PJM-ISO)

What's in the Model:

- Linear optimization: 16352 decision variables, 2172 constraints
- 40 year time horizon (5 year periods)
- 12 generating technologies + MP and CCS coal plant retrofits
- Technologies characterized by: capital, non-fuel VOM, and FOM costs; fuel type; thermal efficiency; max availability; emission control technologies

What the Model Does Not Try to Do:

- Predict MP or CCS technology costs
- Capture demand and fuel price elasticity effects
- Include experience (learning) cost reductions and performance improvements

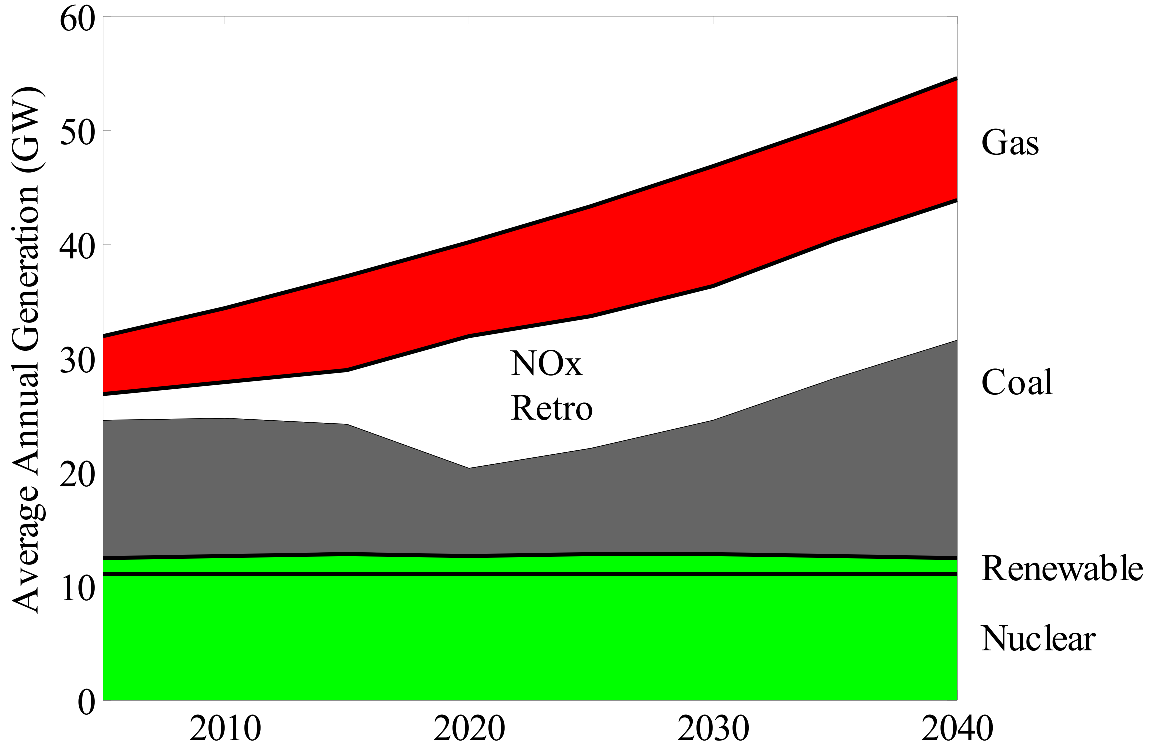
MP (3P) Reduction Scenarios

- BAU (EIA, *AEO2003*): Flat SO_2 and NO_X emissions through 2025; 1.1% CO_2 increase
- “Clear Skies”
- “Jeffords” (3P only; CO_2 limits varied independently)

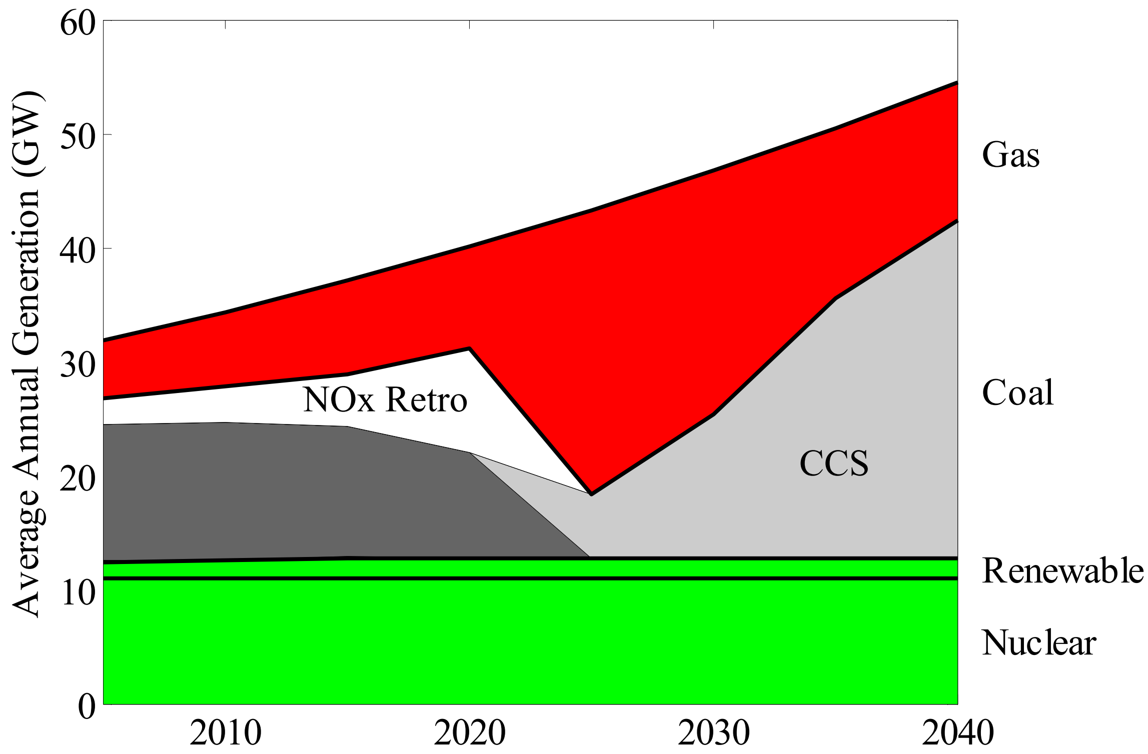
MP (3P) Reduction Scenarios

	% Reduction from 2000 Levels By 2008	2018
	Clear Skies	
SO_2	60 (by 2010)	73
NO_X	58	67
Hg	46 (by 2010)	69
	Jeffords (S.556)	
SO_2	83	-
NO_X	83	-
Hg	90	-
CO_2	23	-

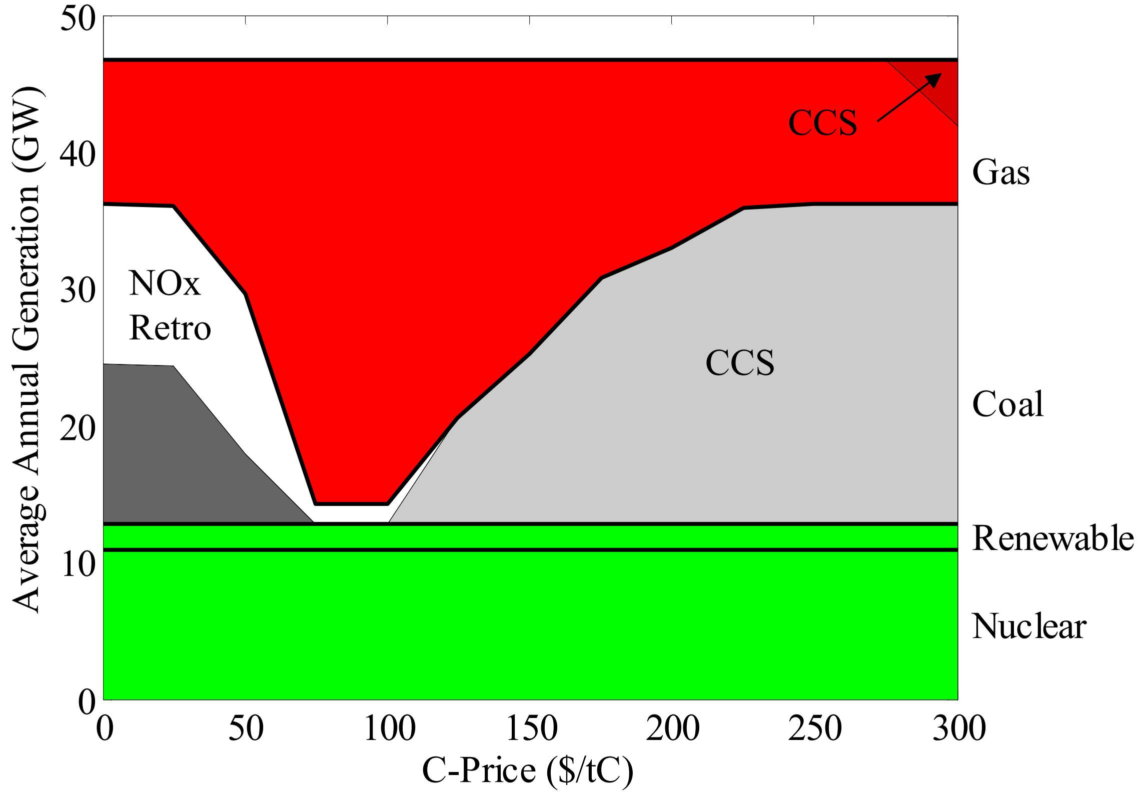
BAU Average Generation vs. Time 0 $/tC



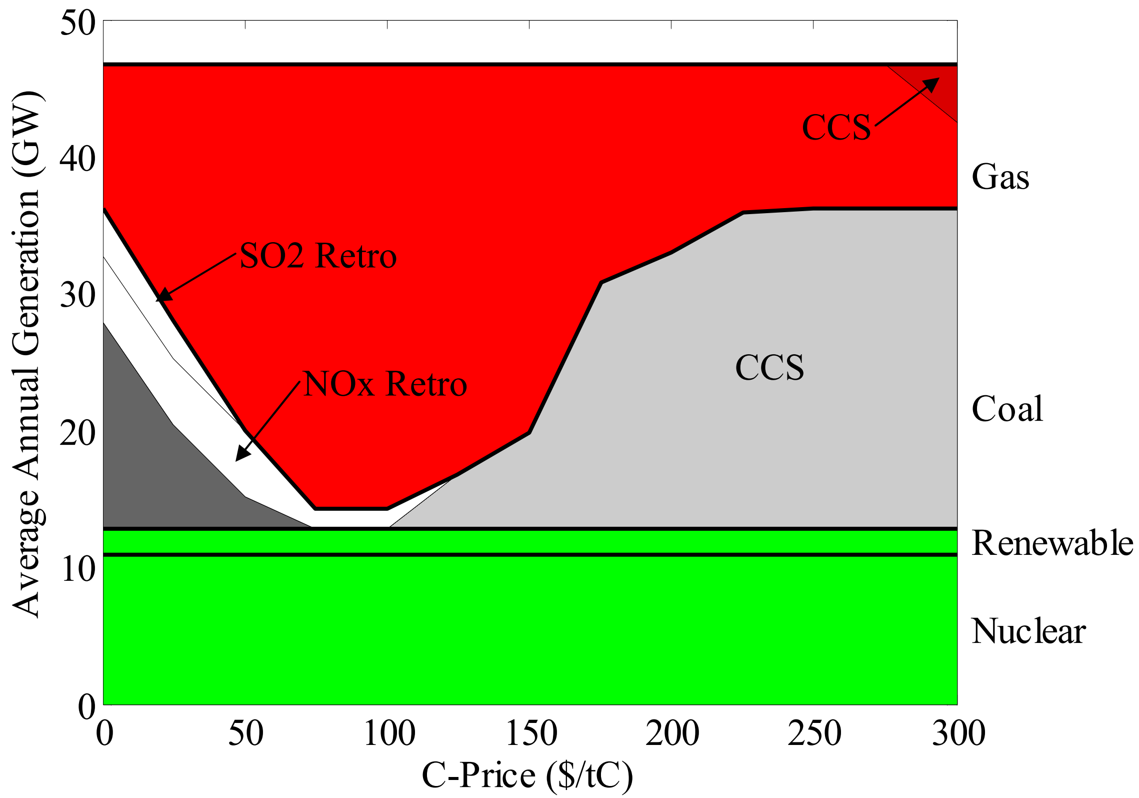
BAU Average Generation vs. Time 150 $/tC



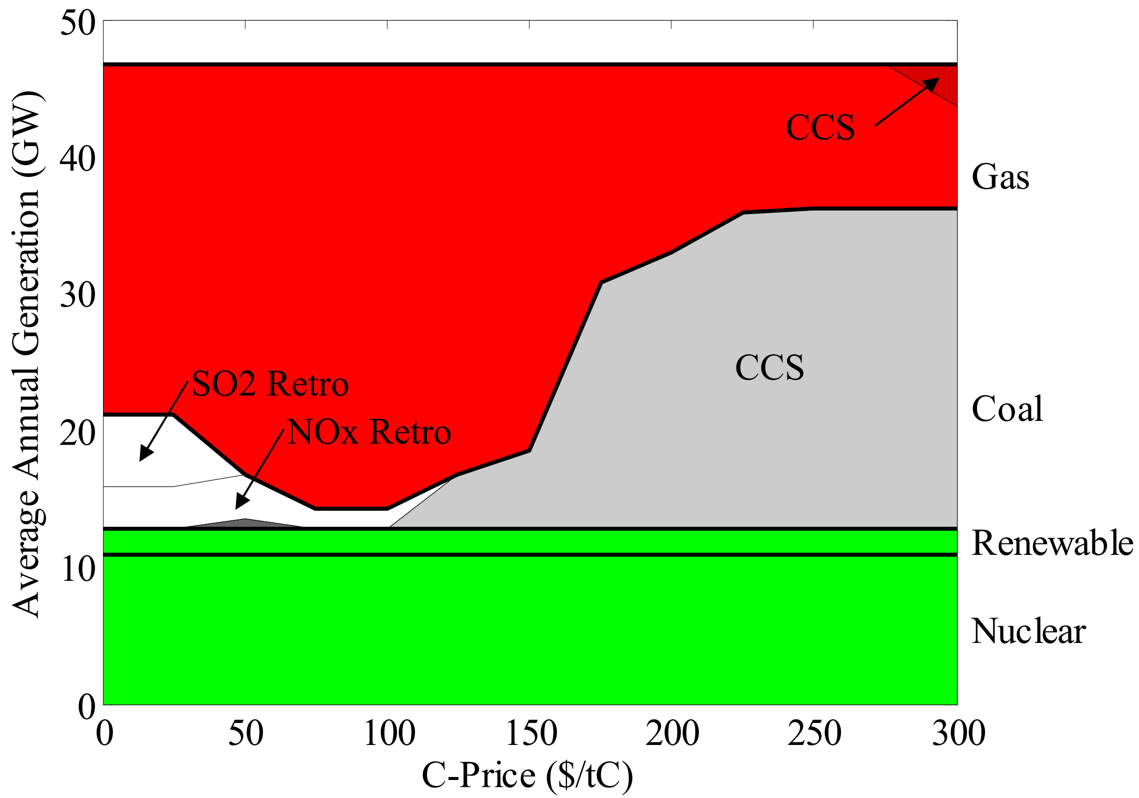
BAU Average Generation vs. C-Price in 2025



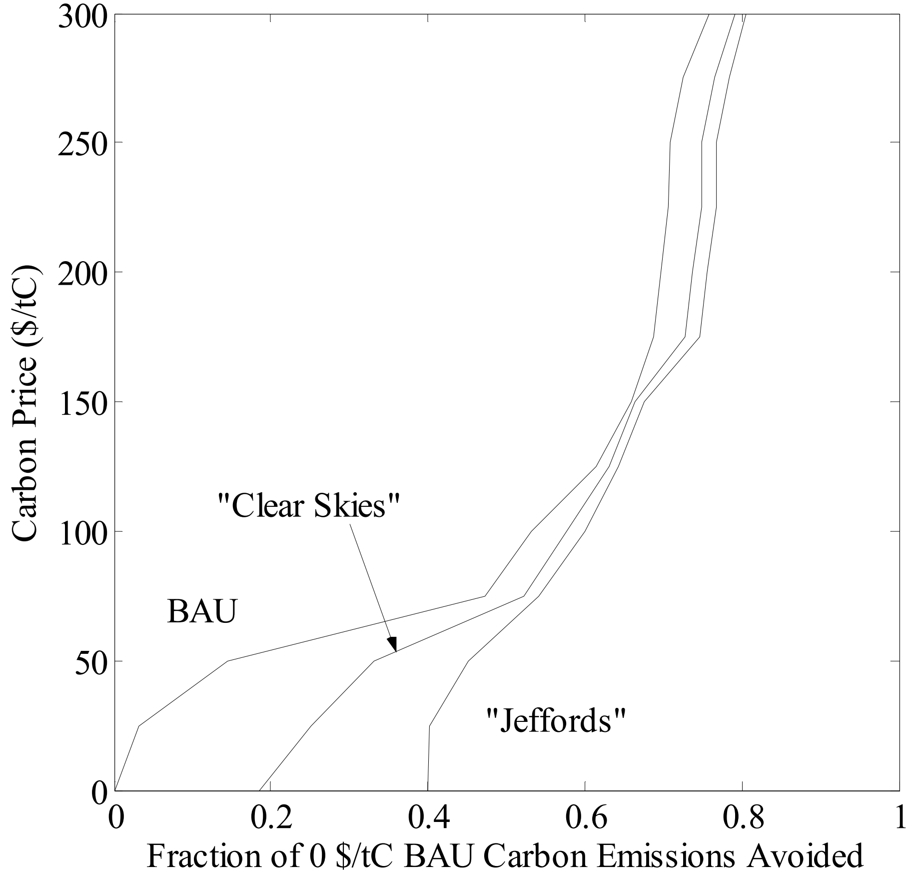
“Clear Skies” Average Generation vs. C-Price in 2025



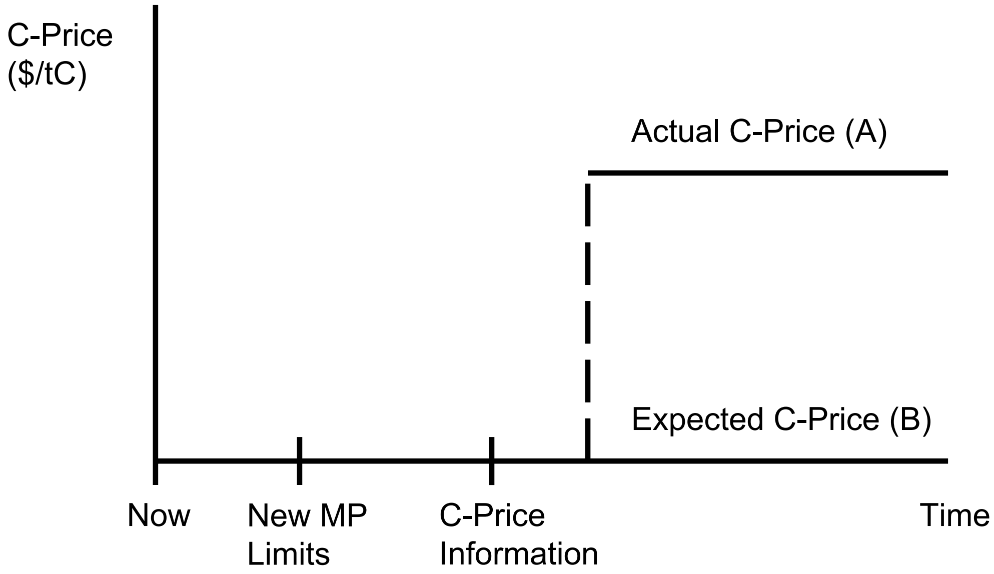
“Jeffords” Average Generation vs. C-Price in 2025



Cost of CO_2 Mitigation



Evaluating Uncertainty: Generic VOI Framework

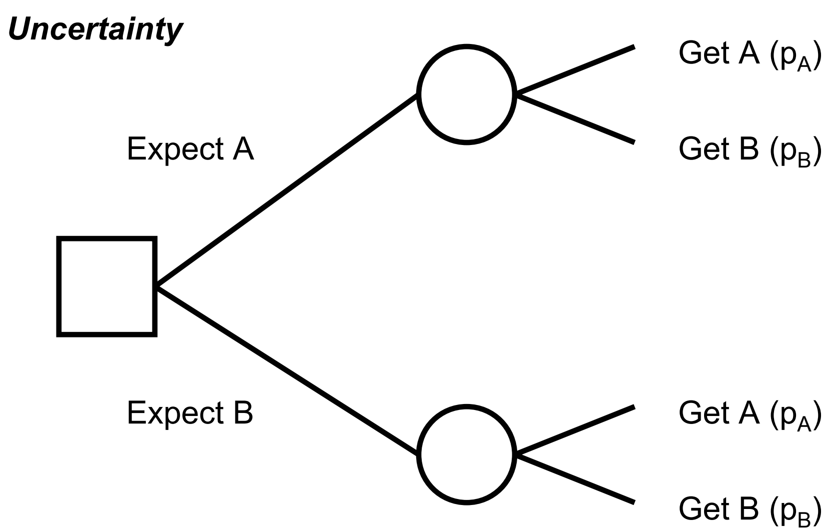


Uncertain Decision Tree

$EV_{Uncertain}$ = minimum of:

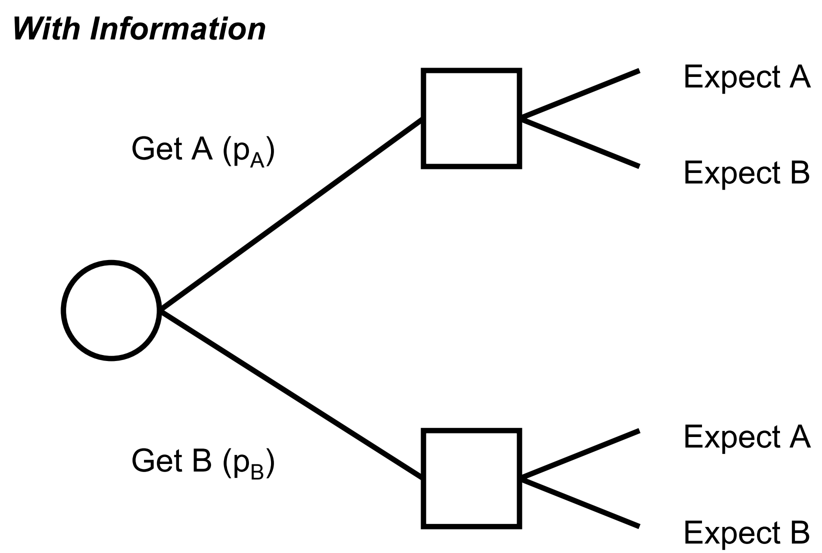
$\{p_A * NPV(\text{Expect A}) + p_B * NPV(\text{Expect A})\}$

$\{p_A * NPV(\text{Expect B}) + p_B * NPV(\text{Expect B})\}$



Clairvoyant Decision Tree

$$EV_{Clairvoyant} = p_A * NPV(\text{Expect A}) + p_B * NPV(\text{Expect B})$$



Value of Information

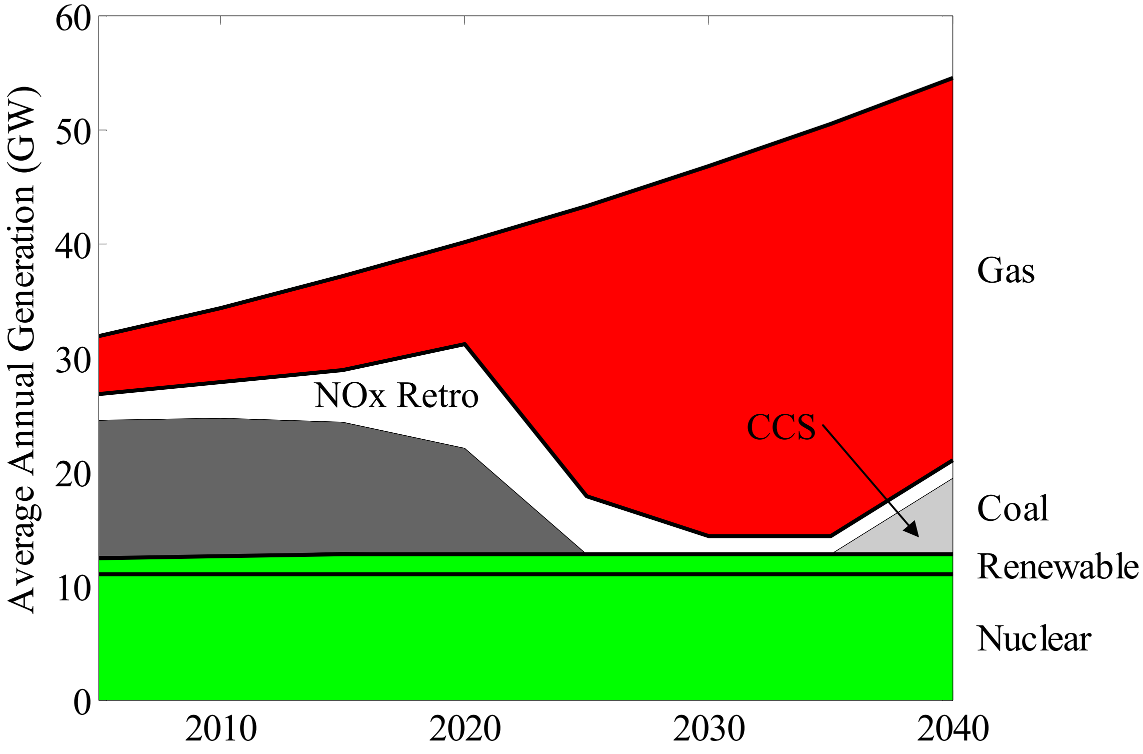
- $VOI = EV_{Clairvoyant} - EV_{Uncertain}$
- But, the largest VOI may occur for an expected C-price intermediate to A and B; the (stochastic) optimization framework takes this into account.

VOI Results

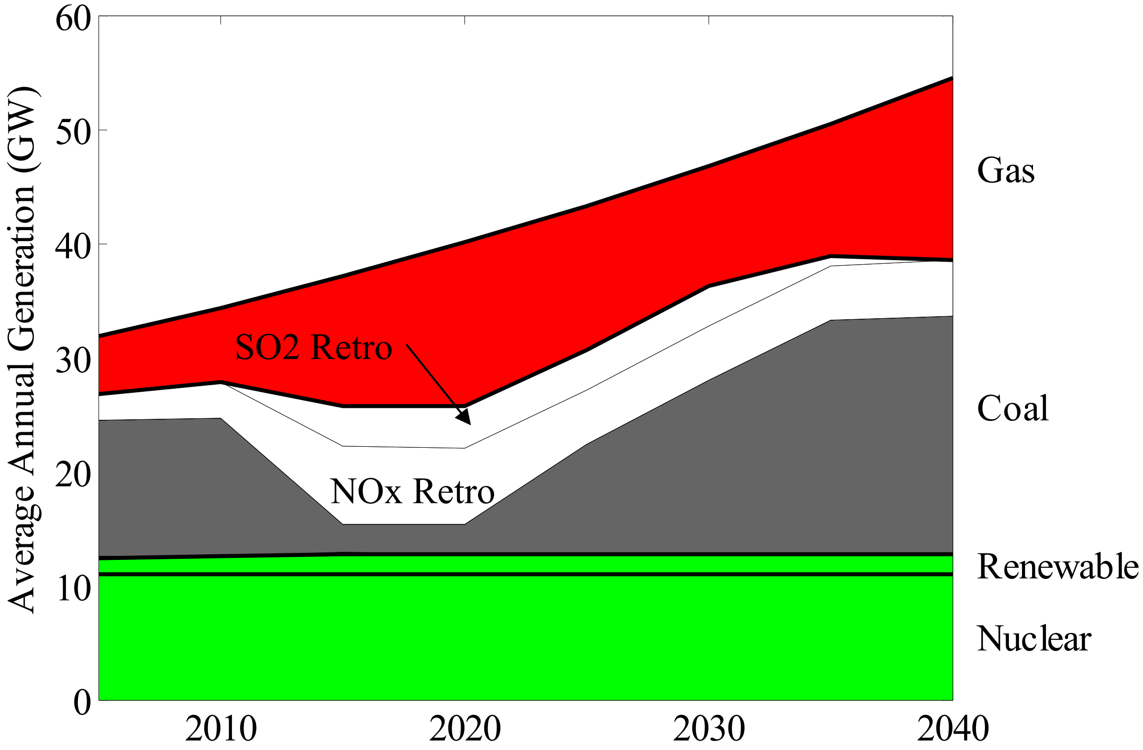
Scenario	VOI for a Step C-price in 2020 (in yr. 2000 100 million $) 75 $/tC	150 $/tC
BAU	1.9	2.3
Clear Skies	3.8	2.8
Jeffords	5.0	6.0

Additional Slides:

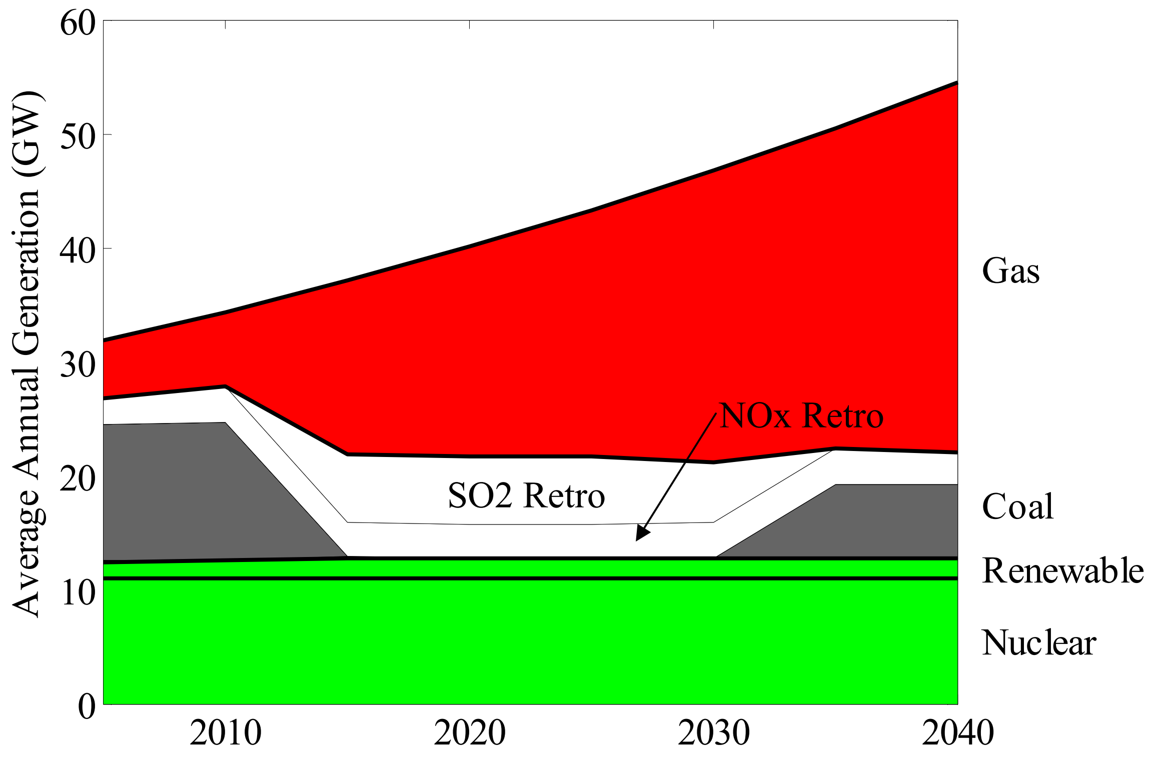
BAU Average Generation vs. Time 75 $/tC



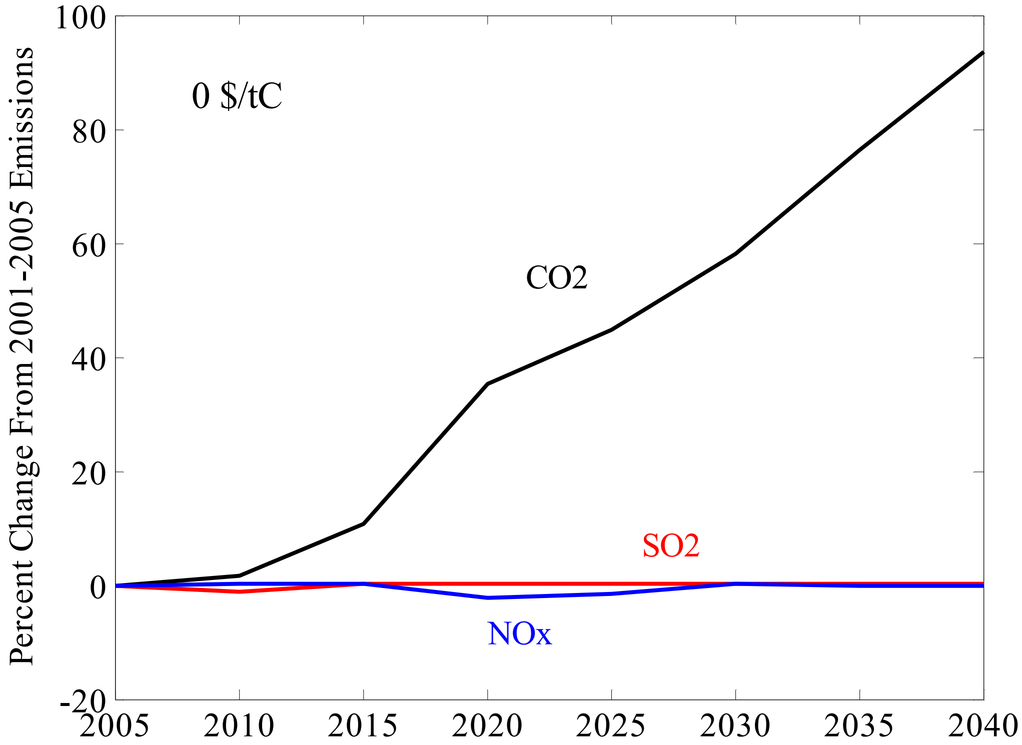
“Clear Skies” Average Generation vs. Time 0 $/tC



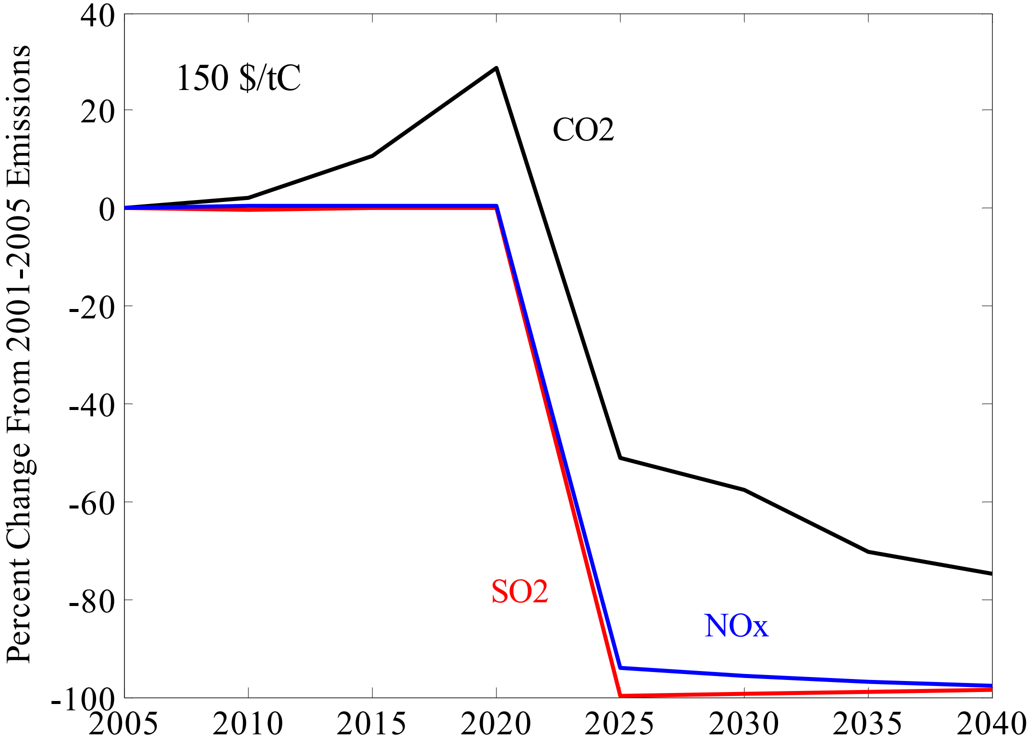
"Jeffords" Average Generation vs. Time 0 $/tC



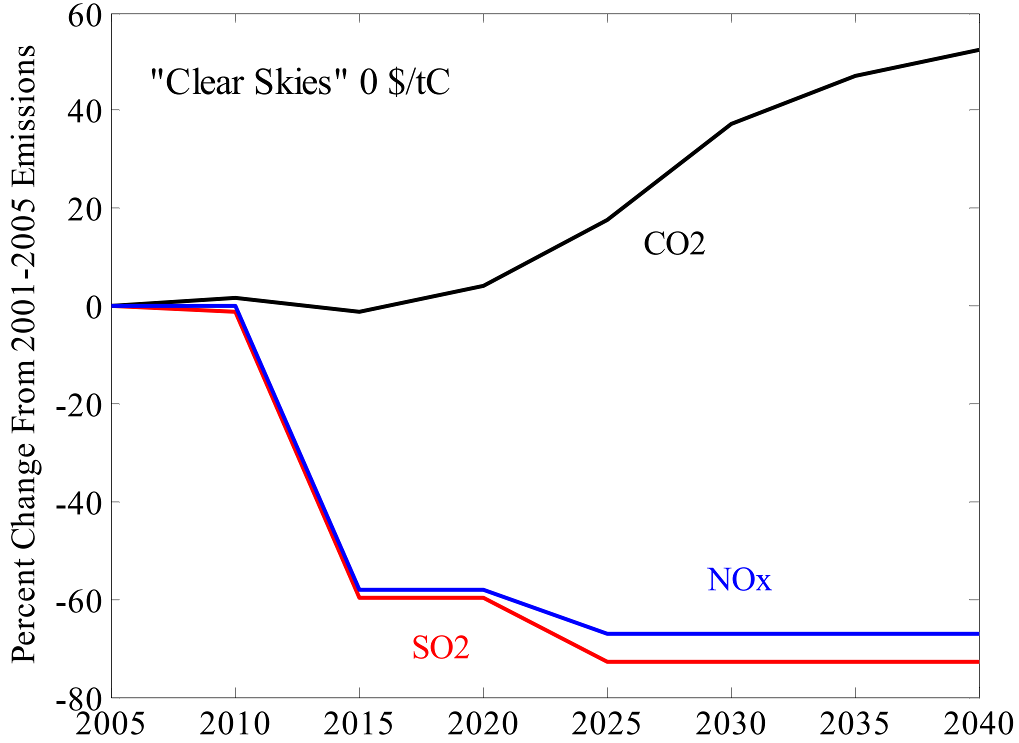
BAU Emissions 0 $/tC



BAU Emissions 150 $/tC



“Clear Skies” Emissions 0 $/tC



“Jeffords” Emissions (w/o CO_2 Cap) 0 $/tC